exhibited, a reference to the table of equivalents is necessary. As for mercury and gold there is much discrepancy among authors, but if we adopt for Hg 100.1 (Erdmann) for Au 196.44 (Berzelius), for Fe 28.04 (Erdmann) and for Cl 35.5 (Berzelius), we have for corrosive sublimate the formula $HgCl$ $(100.1+35.5)=135.6$, and 100 grains would contain Hg 73.82, and Cl 26.18. Now, since the corrosive sublimate in the presence of gold and iron is reduced, and there are formed an amalgam of gold and sesquichloride of iron, we must know how much iron is needed to make that compound with Cl 26.18. The formula for the sesquichloride is Fe_2Cl_3 $(56.08+106.5)=162.58$; therefore in 39.96 grains we have Cl 26.18 combining with Fe 13.78, the quantity sought.

Again, to estimate the gold, assuming the amalgam formed to be in equivalent proportions, we find $AuHg$ $(196.44+100.1)=296.54$; and in 218 grains we discover 144.86 grains of the precious metal, and 73.82 grains of mercury. Or, if we employ the equivalents adopted by Cahours, thus, Au 98.18 (not far from Graham, Au 99.6) and Hg 103), we have 140.92 grains of amalgam yielding 67.10 grains of gold. In short, we need 144.86 grains of gold (or else 67.10 grains) to appropriate the mercury liberated by the action of the reagents. This discrepancy is not likely to lead to ill-results, for, if we use the larger number, we might be quite at ease about the amalgam produced, and it is not certain that the lesser quantity would contribute to form an amalgam more nocuous than the other.

To sum up: For 100 grains of the corrosive sublimate of mercury taken there would be required of iron 13.78 grains, or rather less than the $\frac{1}{7}$th part by weight, and of gold dust 144.86 grains, or about one and a half times the weight, to effect the decomposition of the poison and the complete appropriation of its elements. If we follow Cahours we need only employ 67.10 grains of gold.

In conclusion we would remark, that very large doses of the antidote must be rarely needed, since vomiting, which marks the earliest effects of the corrosive chloride of mercury, necessarily rids the stomach of some portion of the destructive agent.

January 19, 1863.

ART. IV.—*Surgical Cases, Illustrating some Practical Points.* By JOHN ASHHURST, JR., M.D., of Philadelphia.

THE following cases are selected, not from any peculiar intrinsic interest, nor from a supposition that they are in any degree rare or unusual; but because it is believed they will serve to illustrate one or two points in practice about which much diversity of opinion exists, and which the present war ought to settle, if not definitively, at least more certainly than has hitherto been done.

These cases were all advanced into the secondary stage, or that of suppuration, when first brought to the Chester hospital, where I observed them. Had the necessity for operative interference been more quickly recognized, there is no doubt the results would have been more favourable. The statistics of secondary amputation in gunshot wounds are so unsatisfactory, that the operation was only employed when it seemed any other course would insure death. And this, I think, should be the rule; in the case of primary operations, the sooner the better. "Every hour," says McLeod, "the humane operation is delayed, diminishes the chances of a favourable issue." (*Notes on Surgery of Crimean War*, Am. ed., p. 319.) But when the golden opportunity has been lost; when, for any reason, the attempt to save a limb has been made, and the suppurative stage has fairly come on, amputation should not be resorted to, unless the patient's general health begins to give way, when of course the limb must be sacrificed in the endeavour to preserve life.

It is the popular opinion, unfortunately encouraged by some of the profession, in this, as it has been in every other war, that army surgeons are too prone to operate, and that limbs are daily sacrificed that might be saved; but the same conviction is gradually coming to us that was forced on McLeod, on Hennen, on Dupuytren, on Baudens, on Begin, on Larrey, and Guthrie; that, in trying to save limbs, we lose lives. "At the outset of my career," said Begin, "I amputated less than I did toward the end of my service," and the same is the experience of all. I suppose there is hardly a surgeon in the Federal army who does not know of one or more lives sacrificed to "conservative surgery," so called.

I shall narrate the cases I have to report in the order in which they occurred, and shall afterwards call attention to one or two points of interest connected with them.

CASE 1. Private Faulkner, Co. H., 70th N. Y. Vols., was wounded in one of the battles before Richmond in the latter part of August, 1862. A flesh wound of the abdominal parietes in front, and a comminuted fracture of both bones of the left forearm just above the wrist, were the effects of the same ball. He came to the army hospital at Chester, Pa., on September 3d, and was placed in the ward of which at that time I had charge.

As suppuration was already established, and the case seemed to be progressing favourably, the arm was lightly dressed, and kept at rest on an appropriate splint. About the middle of September, however, the limb became much inflamed, and it was rendered evident that the destruction of bone was much greater than had been supposed; and that, in all probability, the wrist-joint itself was involved. At the same time the wounds of the abdominal region assumed an unhealthy appearance, diarrhœa set in, and the patient became daily more prostrated.

Free incisions, soothing applications, and all means that a desire to save the limb could suggest were employed, but without avail; and on the 25th September it was decided, in consultation, that the forearm must be removed.

I accordingly performed the operation the same afternoon, the patient being under the influence of ether, by the method of Mr. Teale. Sixteen ligatures were applied, the flaps brought together by points of lead suture, and the stump kept wet with an anodyne wash. Light, but nutritious diet, six fluidrachms of brandy every hour, with tonics and anodynes cautiously administered, constituted his treatment. The patient rapidly improved, the flaps adhered throughout, except where the ligatures escaped, and recovery followed without a single unfavourable symptom. When I last saw this man, in December, he was awaiting his discharge, not having been under any treatment for a long while, and his stump as full and plump almost as on the day of operation.

CASE 2. Corporal Warren, Co. H., 20th Mass. Vols., at the battle of Antietam, September 17th, received a gunshot fracture of the right humerus, and entered the Chester hospital on the 2d October following. The next day a portion of ball was removed by a counter-opening on the outside of the arm, the track of the original wound being antero-posterior, and in the middle third. Subsequently the wound of entrance was enlarged, and a fragment of bone, which was loose, extracted. By the finger, which could be easily introduced into the posterior wound, that of exit, it was found that a large fragment of the lower part of the humerus was dead and partially loose. It was therefore determined, in consultation, to enlarge this wound, remove all loose pieces of bone, and, if necessary, saw off the projecting extremities of either portion.

Accordingly, on the afternoon of the 11th, the patient was brought under the influence of ether, and a free incision made longitudinally downwards from the wound of exit. It was found, by the examination which could now be made, that the destruction of bone was much greater than had been at all imagined, and resection was resolved upon, which it was supposed would give a reasonable prospect of preserving the limb.

Access to the bone was facilitated by a transverse incision, starting also from the wound of exit, the upper end of the lower fragment removed by means of a metacarpal saw, and the projecting part of the lower fragment by bone-nippers. Only a few small vessels required ligature, the wound was accurately closed, and the limb placed at rest on a splint. With the exception of a very profuse suppuration and consequent failing strength of the patient, everything progressed favourably until early in the morning of the 18th, one week after the operation, when a profuse secondary hemorrhage took place, stopping of itself by the time I reached the ward.

It was now decided, should hemorrhage recur to any considerable amount, as the patient was already much weakened by suppuration and the subsequent loss of blood, to perform amputation above the seat of injury.

Another hemorrhage, of a still more alarming extent, did take place the next afternoon, and, accordingly, the patient being under the influence of ether, I removed the arm in its upper third, oval skin-flaps being obtained from the front and back of the arm, and the muscles divided by a circular incision higher up. Very little blood was lost, thirteen ligatures being employed, and the flaps brought together by the lead suture. For several days the patient hung between life and death, but nature finally triumphed, and recovery, after amputation, was even more rapid than had been the sinking after the "conservative" operation of resection.

Case 3. Corporal Burnham, Co. D., 132d Pa. Vols., admitted also on October 2d, with a gunshot fracture of the left radius, received at the battle of Antietam. For some weeks the case was treated by the ordinary methods, but at the end of that time it was found that the radius had become necrosed for a space of about three inches, and apparently in its entire thickness. Resection was at first proposed, but, in view of the man's broken down condition, the risk of secondary hemorrhage or sloughing, and consequent necessity for a subsequent operation, and the patient's own expressed preference for amputation, the latter course was adopted, and I removed the forearm a short distance below the elbow on October 28th, by making two oval flaps, antero-posterior, cut from without inwards, the patient being under the influence of ether. Consecutive hemorrhage required the stump to be opened the same evening, and finally could only be stopped by plugging either bone with a pellet of wax, and inserting several thicknesses of patent lint between the flaps, which were then held together by strips of adhesive plaster.

Oct. 30, both flaps presented healthy granulations, the lint was removed, and the flaps kept in position as before.

Nov. 2 (five days after the operation), a secondary hemorrhage. On opening the stump the bleeding vessel was found and tied.

Nov. 4th, 4 A. M., another hemorrhage, stopping of itself, and followed by still another about three hours later. It was now determined to ligate the brachial artery, which was accordingly done, the patient reacting with difficulty from the anæsthesia which had been again produced, and being exceedingly feeble from the repeated loss of blood. The brachial artery was found to have divided high up, and both branches were accordingly secured. For some days he seemed to improve, then sloughing and numerous abscesses around the joint followed, hemorrhage recurred from both wounds, and death closed the scene on November 15, eleven days after the ligation of the brachial artery, and eighteen after the amputation. No *post-mortem* examination was obtained.

Case 4. Private Donnell, Co. B., 27th N. C. Regt. (rebel prisoner), also wounded at the battle of Antietam, and admitted on October 2d.

The wound, which appeared to be simply a flesh wound, did well, and was nearly healed, when, from some then unknown cause, the track reopened, and by the probe and little finger dead bone was detected about the middle of the left femur. After some time rigors and hectic supervened, and it became evident that, unless an operation could alter the state of things, death must inevitably occur, and that in a very short time. Amputation was accordingly determined on, and the patient being etherized, I removed the thigh about the junction of the upper and middle thirds by the circular incision on the afternoon of November 6. The patient with great difficulty reacted from the state of anæsthesia, but subsequently sank suddenly, and died seven hours after the operation. The femur was found necrosed in its entire thickness, and a large mass of soft callus had been thrown out, between which and the dead shaft a foyer of pus existed.

The points to which I wish to refer in these cases, and which I consider of great practical importance are: 1. Resection in the continuity of long bones as a substitute for amputation, and as an aid to nature in compound fractures. 2. Ligation of main arteries as a remedy for secondary hemorrhage. 3. The importance of amputating soon when the operation is to be done at all.

The excision of the articular extremities of the long bones for injuries of the joints is an operation now firmly and justly established as truly conservative. The removal of portions of the shaft of long bones for necrosis has been done with occasional good results. "Such operations, however," says Holmes, "whether undertaken on account of caries or necrosis, too often result in failure." (*Syst. of Surgery*, vol. iii. p. 830.)

The same author, in his edition of Wagner's treatise on the process of repair after resection and excision of bone, has collected seven cases of resection from the substance of bone, only three of which, however, are apposite to the present discussion. In one of these, the ulna being the bone concerned, "the movements of the arm including rotation, were almost perfectly restored." In another, where a great part of the tibia was removed, after three-quarters of a year, "in spite of the uninjured fibula, shortening of more than two inches had occurred." While in the third, also a resection of the tibia, "the limb remained useless, and the leg was amputated eight months afterwards." (*Selected Monographs.* New. Syd. Soc., pp. 239–240.)

These were resections under favourable circumstances, for in operations for disease, the periosteum can generally by preserved, thus giving a chance for the formation of new bone.

A great deal is said at the present time about subperiosteal resection. "Some writers," says Mr. Holmes, "speak about subperiosteal resections of joints, in such terms that one is almost disposed to think that they imagine the possibility of dissecting out the end of the shaft of a large bone, like the femur or the humerus, and leaving behind a sleeve of periosteum, which is to reproduce the bone. Such an idea is preposterous.

The attempt would only result in leaving some irregular shreds. M. Ollier's experiments show that such shreds will, in the lower animals, produce irregular nodules of bone. Probably this would not be so in man; but if it were, such nodules would be more often in the way than otherwise." (*Syst. of Surgery*, vol. iii. p. 803.)

Ollier has indeed gone further than this, and has shown that in animals, an entire articulation may be reproduced; and even suggests a new operation, "*osteoplastie périostique*," as being quite possible. Although, however, nearly four years have elapsed since the publication of his paper (*Journal de la Physiologie de l'Homme et des Animaux*, Avril, 1859), I am not aware that even an attempt has been made to carry out his proposal.

But whatever may be the results and prospects of resection in cases of necrosis, gunshot or other injuries present a different position of affairs; here the preservation of the periosteum may be looked upon as practically an impossibility, and the best result that can be hoped for is a shortened and twisted limb. If the end of a broken bone project through the skin, and the fracture can in no other way be reduced, it would seem reasonable to saw off the projecting portion, and thus remove the obstacle to the proper adjustment of the fragments. But if this particular contingency be not present, and deep and long incisions be required to expose the injured bone, the question is different. If the destruction be so great as to render an operation of any kind necessary, I doubt if true conservatism would not point to amputation; because for one limb deformed and helpless perhaps, which resection might save, I fear that more than one life would be sacrificed.

Hence, should another case like that of Corporal Warren occur to me, I should avoid all operative interference as long as possible, and if it became finally indispensable to do anything more than the mere removal of sequestra, I should advise amputation at or above the seat of injury.

The utmost, I conceive, that resection in such a case could accomplish, would be the preservation of a limb of doubtful utility. "I cannot," says Mr. Holmes, "discover any evidence of the restoration of the continuity of a long bone after its interruption by the resection of a piece of its shaft, except in cases of necrosis. Probably if the piece were very short, union might occur; but the necessity for the removal of such a piece could hardly ever arise." (*Syst. of Surgery*, vol. iii. p. 830.) To all the risks of a compound fracture, the risks of a capital operation are added; and if the necessity for subsequent amputation, as in my case, arises, it is not always that the patient is so fortunate as to survive his complicated dangers.

No accident following operations is more harassing to the patient and more feared by the surgeon than secondary hemorrhage, and it might seem strange that the profession have not yet arrived at any unanimous conclusion as to the best means of remedying so dreadful an occurrence. Most surgeons, if not of the present day, at least quite recently, have supposed that ligation of the main artery above the seat of hemorrhage was the safest and surest way of checking bleeding. But the fact brought so prominently forward by Guthrie, that secondary hemorrhage in almost all cases is from the lower or distal end of the wounded vessel, explains the frequent failure of this operation. Undoubtedly when it is possible to do so, Guthrie's recommendation should be carried out; viz: to cut down at the seat of hemorrhage and secure both ends of the bleeding vessel. But in many cases this is impossible. By the time the bandages and dressings are removed the hemorrhage has ceased, and the bed soaked in blood, and the patient's fluttering pulse are all that remain to tell of the occurrence. In such a case forced flexion of the limb, or pressure upon the main vessels, will sometimes prevent a return of the bleeding; but, as a general thing, ligation of the artery above, or amputation, are the only means that promise success; for the most careful scrutiny may fail to discover any patulous arterial mouth.

Ligation is of course looked upon with favour, as giving a chance of saving the limb.

I can recall very well a case in the Pennsylvania Hospital, where, for hemorrhage, the radial, then the ulnar, and finally the brachial artery was tied; and the man's life and limb were both saved. But I fear such cases are exceptional. The use of the actual cautery, introduced into the bleeding artery through a canula, as practised by Mr. Cline (*South's Chelius*, Am. ed., vol. i. pp. 347–352) would, I should suppose, be very efficient, but for the fact that in most cases of secondary hemorrhage it is impossible to find the bleeding vessel.

In compound fractures, whether from gunshot wounds or other causes, ligation of the principal artery will not only generally not succeed in permanently arresting hemorrhage, but superadds a considerable risk of gangrene; while even in bleeding from stumps, where it would seem to promise more favourable results than under any other circumstances, it too often proves unavailing, and subsequent amputation or death obliges the unwilling surgeon to record it among his unsuccessful operations.

A case, narrated by Bertherand, seems so appropriate in this place as to merit more than a passing reference:—

"Captain O——, who had been wounded in the upper third of the forearm by a ball which passed between the two bones, after a considerable time had a hemorrhage which was attributed to a wound of the interosseous artery. After vain efforts to control it by the application of Signoroni's compressor, the usual hæmostatics, compression direct or remote, the brachial artery had to be tied. In spite of this remedy, which one might suppose would be final, the hemorrhage soon returned. I was asked to see the patient. He was lodged with an excellent *confrère*, who, with his wife and two daughters, maintained from hour to hour a digital compression on the wounded limb. Having assured myself of the reality of the ligature of the principal trunk, I probed the wound and took away with my forceps a fragment of lead. I then passed into the track a mesh saturated with a solution of the perchloride of iron, and the bleeding was arrested. As the lower end of the vessel might be the source of the accidents, I advised the application of a gauntlet bandage and graduated compresses, methodically bound, as well on the face of the limb as in the interosseous space, and continued as high as the wound, an elevated position for the hand, perfect rest, and digital compression in the axilla. In spite of these precautions the dressings were again the next day tinged with red, and the patient sinking, all resources having been exhausted, we had to be resigned to the cruel necessity of amputation.

"I have since learned that Captain O—— was not able to support its consequences." (*Bertherand, Campagne d'Italie*, pp. 159, 160.)

Who can say that here the "humane operation" in the first place would not have been truly conservative. I am aware that the doctrine I am advocating is in opposition to the views of many, probably a large majority, of the most eminent names in surgery; but I am well convinced that had I in Corporal Warren's case tied the brachial or axillary, instead of amputating, he would not now be alive; while, on the other hand, if in Burnham's case I had amputated above the elbow, instead of tying the brachial, it is not impossible that the result might have been different.

The third point to which I wish to direct attention is the importance, when an amputation is certainly to be done, of doing it as soon as possible. Many a life has been sacrificed to the hope of getting the patient in a better condition before operating. It should be remembered that the shock of an operation, particularly with the use of ether and opium, is a very slight matter; while the presence of the limb to be sacrificed is a positive and constant depressing agency.

Had Faulkner's arm been left on a few days longer, in the hope of his being better able to support the operation, I believe the operation would have come too late. Had Donnell's thigh been sacrificed at the first manifestation of unfavourable symptoms, his life might possibly have been preserved.

On the other hand, no secondary amputation should be performed for mere *probable* cause; for the ability of nature to relieve herself by throwing off sequestra, &c., is sometimes almost incredible. If the operation be inevitable, or if the patient be manifestly failing day by day, hesitation may become fatal; but while the health is kept up, and the effort seem not too great for nature unaided, expectancy remains the proper mode of treatment.

The inferences which have been forced upon myself by a careful review of the cases above narrated may be thus summarily stated:—

I. When the injury is recent, in any case of doubt the limb should be amputated. For one limb needlessly lost, many lives will have been saved.

II. Resection in the continuity of long bones is not a substitute for amputation; and except in the one case of a bone projecting through the skin, and otherwise irreducible, is not an assistance to nature in the treatment of compound fractures.

III. Ligation of an artery above the wound is too often unavailing as a means of checking secondary hemorrhage; and in many, if not most cases, amputation is a safer remedy.

IV. No secondary amputation should be performed for *probable* cause only; but if certainly requisite, or if the patient be evidently sinking, delay, even the slightest, is to be deprecated, and often will, unhappily, prove fatal.

PHILADELPHIA, February, 1863.

ART. V.—*On Compound Comminuted Fracture of the Femur from Minie Balls.* By A. E. CAROTHERS, M. D., of Newburg, Cumberland County, Penna., and formerly Act. Asst. Surgeon U. S. Army.

THE character and extent of the injury caused by the minie ball in the bony tissues, and especially in the compact substance of the shaft of the long bones, as the femur, is very different from that caused by any other projectile used in modern warfare.

The weight of the ball, its velocity, and the great momentum resulting therefrom, combined with its rotatory motion, serve to cause a fracture differing from that produced by the ordinary round ball, by the great comminution, by the disposition of the lines of fracture to extend along the bone in the axis of its length, and also by the tendency of the fragments to separate from their continuity and be driven off into the contiguous muscles. I have seen a *transverse* fracture of the femur caused by a minie ball, at least four inches above the point at which the ball impinged on the shaft of the bone, resulting from *momentum* of the ball being transmitted along the shaft of the bone, until a point was reached at which the resistance of the femur counteracted it, at which point a fracture was produced by the opposing forces.

It having been my fortune to meet, during the term of my service in the U. S. Army, quite a large number of compound comminuted fractures of the femur from minie balls, I purpose to give a brief resumé of the cases, with a detail of their treatment and results, as nearly as possible from the few hasty notes which I was able to take at the time, and from my own recollection of the cases.

My first cases were three soldiers wounded at the battle of Cedar Mountain, August 9th, 1862, in the U. S. General Hospital at Culpepper Court House, Va., who were placed in my ward as hopelessly injured. They had all extensive comminuted fractures of the middle and upper thirds of the femur.